Replacement of the Amy Street Rail Overbridge (in two weekend track possessions) at Regents Park, Sydney

Vincent Scolaro[1], Jeffrey Geronimo[2], and Emaline Lim[3]
[1]Technical Director, Beca P/L
[2]Senior Civil Structures Engineer, Beca P/L
[3]Civil Structures Engineer, Beca P/L

Abstract: Built in 1921, the existing bridge is a two-span (6.4m & 9.45m) Jack Arch superstructure supported on unreinforced masonry abutments and central pier. The bridge spans over the railway line and carries two lanes of traffic with narrow footways along both edges. The abutments act as retaining structures that are partially propped at the top by the superstructure.

Road traffic required this bridge to be widened to accommodate 4 lanes of traffic and tie-in to the existing roads at each end. Rail traffic required the bridge to accommodate future addition of two rail tracks and increased vertical clearance for overhead wiring maintenance.

The final design allows for the demolition of the existing bridge and provision of a new single span bridge. The envelope and clearances as determined by Auburn Council and Sydney Trains have been adhered to in the design.

The new deck consists of steel WC girders with cast-in-situ concrete deck slab. The abutments consist of concrete headstocks over bored piles built behind the existing abutments. Steel girders were selected and the deck slab built integral with the abutments to maximize vertical clearance.

Construction is only allowed two weekend track possessions with the second possession provided as allowance in case construction went behind schedule. Prior to first possession, the new abutments were built. On the first possession, the superstructure and central pier of the existing bridge was demolished and the new girders installed. The edge girders came with precast fascia panels to serve as safety railing during construction. Second possession tasks include the demolition of the existing bridge abutments and finishing the new bridge.

This paper outlines how innovative construction methodology was included in the design to address construction program issues (bridge construction in one weekend track possession) and tight site constraints at each end of the bridge.

1 Introduction

The Amy Street Intersection consists of an overbridge crossing over the Sydney Metro T3 Bankstown Rail Line, linking Park Road/Carlingford Street on the north-west to Auburn Road/Amy Street on the south-east. The intersection is adjacent to, and south of Regents Park Rail Station. The overbridge, Auburn Road/Amy Street and Park Road/Carlingford Street all consist of 2 traffic lanes (one in each direction).

The existing overbridge, built in 1921, was a two-span (6.4m & 9.45m) Jack Arch superstructure supported on unreinforced masonry abutments and central pier (see Figure 1) supports two lanes of traffic (one in each direction) and two narrow footpaths on both sides of the bridge. The existing bridge had a minimum clearance of 5.1 m from the top of rail to the soffit of the superstructure, with overhead wiring attached to the soffit of the superstructure.

In 2013, Auburn Council proposed the upgrade of the intersection, with the aim of improving traffic flows and increasing capacity. The upgrade works included:

- Replacement of the existing two-lane bridge with a four-lane bridge
- Two-lane circulating roundabout at each end of the bridge
- Associated tie into existing road kerb line of Amy Street, Auburn Road, Park Road, and Carlingford Street

Provision for future further works was also considered, including the possible widening of Auburn Road and Carlingford Street. Auburn Council selected Abergeldie Complex Infrastructure to be the main D&C contractor, who in turn engaged Beca as the lead designer.

Figure 1. Existing Amy Street overbridge as viewed from Regents Park Station

Surrounding constraints and features of the site include:

- An existing Sydney Water pipeline bridge crossing over the rail tracks approximately 30 metres to the south of the road bridge.
- Regents Park Station platform approximately 15 metres to the north of the existing road bridge.
- Building developments adjacent to Park Road/Carlingford Street and Auburn Road/Amy Street.
- Rail Infrastructure (signals, OHW gantries, OHW attachment to the existing bridge) within the rail corridor.
- The newly built Transgrid 330kV cable bridge approximately 20 metres south of the road bridge.
- Existing Telstra conduits embedded in existing bridge deck to be retain and integrated into new bridge.
- The overhead wiring (OHW) fixed to the soffit of the existing bridge

Figure 2. Project site – original layout

2 Design Development

2.1 Original Detailed Design (March to December 2013)

The original Beca design completed in 2013 provided 4 x 3.2 m wide lanes on a 15.1 m wide superstructure. As per council specification, the overbridge was designed for T44/L44 loading. The superstructure consisted of a 180 thick cast in situ deck supported on 17 No. 600 x 600 standard RMS Precast PSC Planks. The existing bridge central pier was to be demolished, creating a single simply supported span 16.484 m. The planks were to be supported on elastomeric bearings on the existing brick masonry abutments, with the existing brick masonry abutments strengthened to resist rail collision loads specified in AS 5100.2 – 2004. The overheads wiring was also to be detached from the existing bridge and supported by a new OHW structure to the north of the bridge. An elevation of the original bridge design can be seen in Figure 3 below.

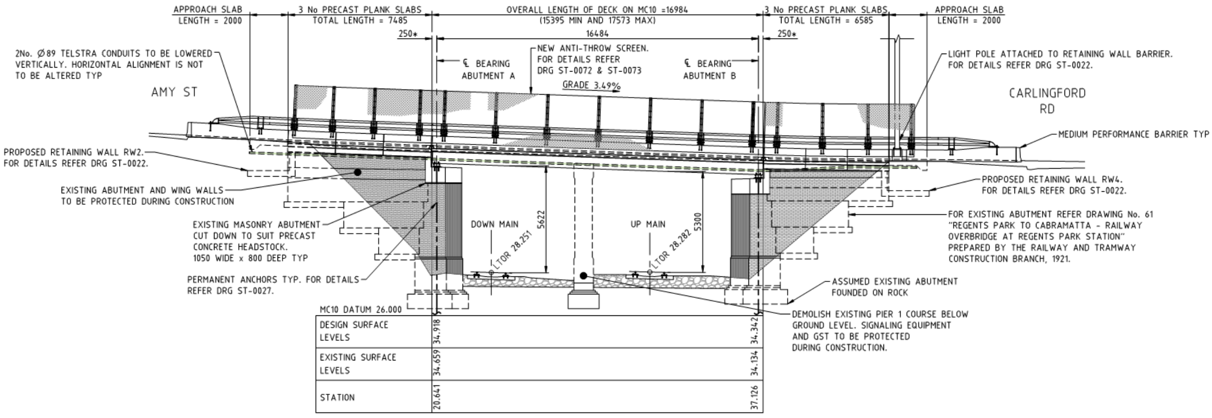


Figure 3. Elevation of original design

The design provided no change in horizontal clearance, and an improvement to the existing vertical clearance with a minimum clearance of 5.3 m from the soffit of the superstructure to the highest rail. Beca submitted a concession to RailCorp (later becoming Transport for New South Wales; TfNSW) for the approval of the vertical and horizontal clearances. The concession was expected to be approved as the proposed design did not increase the risk profile of the structure. Whilst awaiting TfNSW approval, Beca was instructed to proceed and complete the detailed design. Upon review by TfNSW, the concession was rejected and by extension, the completed design.

2.2 Concept Design Options (November to December 2014)

TfNSW rejection of the concession and 2013 design was on the basis of insufficient vertical clearance, which would provide improved access for the maintenance of OHW. Furthermore, TfNSW intended to increase the horizontal clearance beneath the overbridge to make provision for two new rail tracks in the future. The project scope was revised in 2014 to incorporate TfNSW requirements for future proofing and clearances. Beca was commissioned to present additional concept bridge options as an alternative to the original 2013 design. Beca prepared six options, all of which included the lengthening of the overbridge for increased compliant horizontal clearances and varying vertical clearances. Beca presented the new options to Council and TfNSW in December 2014 during which the preferred option was selected.

2.3 *Revised Detailed Design (July 2015 to January 2016)*

The selected design reused the existing bridge alignment, providing a minimum clearance of 5.7 m to the highest rail. This clearance was deemed to be sufficient for maintenance access, despite being less than the clearance of 6.5 m specified in ESC 215.

An elevation of the revised design of the overbridge can be seen in Figure 4. The superstructure was designed for SM1600 load as per AS 5100.2 – 2004 and consists of a composite 200 thick concrete deck on 13 No. 500 WC 440 steel beams. As per the original 2013 design, the overhead wiring was also to be detached from the existing bridge and supported by a new OHW structure.

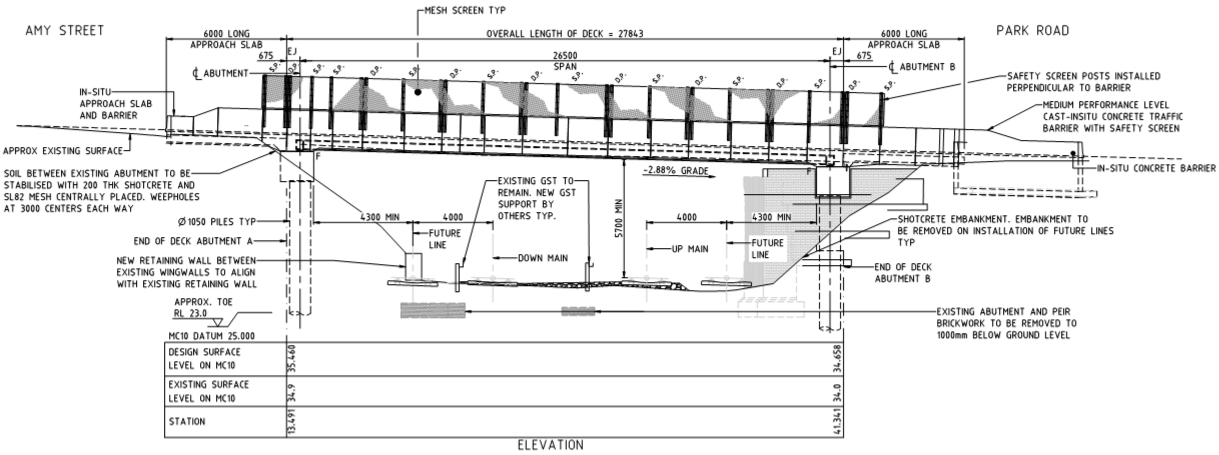


Figure 4. Elevation of revised detailed design

The steel beams span 26.5 m over the rail line and are supported on cast in situ headstocks on 1050 mm diameter cast in place piles. Portions of the cast in situ headstocks were cantilevered to accommodate limitations in piling rig access due to the sloping embankments on either side of the existing abutment. Provision was made for the encasement of the existing Telstra conduit and future utilities within the new bridge superstructure, as can be seen in Figure 5.

The steel girders were made integral with the cast in situ concrete abutments to reduce depth of the girder required and also to reduce the midspan deflections and design actions, facilitating a thinner superstructure and improved vertical clearance over the rail. The negative moments were transferred from the superstructure to the substructure via a combination of anchored reinforcing bars and shear studs welded on a plate at the end of the girders.

The 100% revised detailed design consisted of a standard RMS 1.3 metre high medium performance level concrete barrier with twin steel traffic railing. Anti-throw screens were detailed on the outside of the barriers, comprising of a combination of mesh and solid clear polycarbonate sheets. The polycarbonate sheets were detailed over the OHW as vertical safety screens in lieu of the conventional horizontal safety screens; as horizontal safety screens were not preferred by TfNSW due to difficulties with maintenance. The proposed polycarbonate vertical safety screens were also rejected by TfNSW at 100% design due to maintenance requirements. As such, Beca revised the barriers to 1.3 m high concrete barriers by removing the steel railings and replacing the polycarbonate sheets with steel mesh, eliminating the need for vertical or horizontal safety screens.

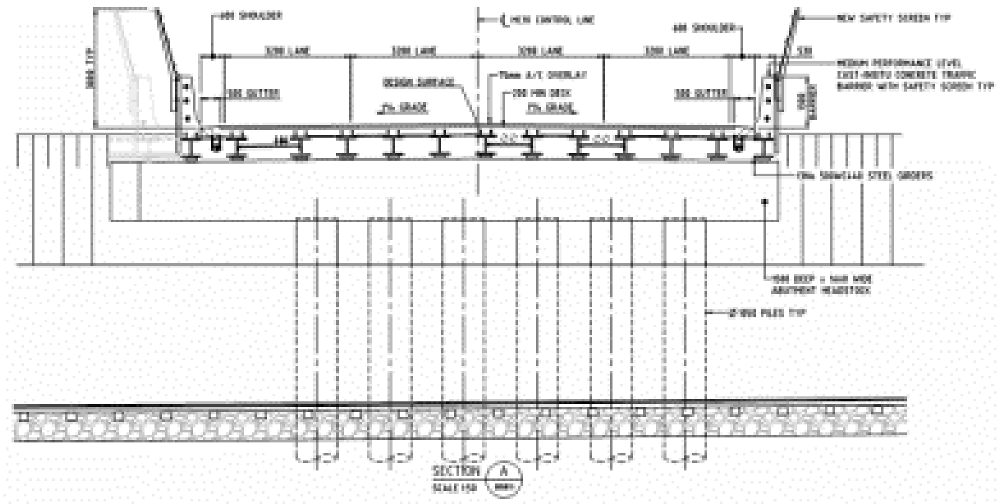


Figure 5. Cross section through revised detailed design

The anti-throw screens were designed to be fixed onto the outside face of 105 mm thick precast concrete fascia panels. These fascia panels were temporarily fixed onto the girders via PFC hold down brackets and levelling bolts welded onto the top flange of the girders. Cast-in Unistrut sections were provided for the attachment of the fascia panels to the PFC hold down brackets to enable on-site adjustment. A typical section of the temporarily supported fascia panel is provided in

Figure **6** below. The fascia panel served as formwork for the concrete road traffic barrier and safety barrier for the construction workers during construction of the deck slab and ensuing works. The fascia panel further served as a façade, concealing a portion of the steel girders.

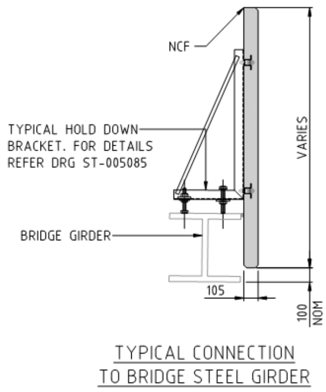


Figure 6. Fascia panel temporarily supported via PFC hold down brackets

3 Innovations in Construction

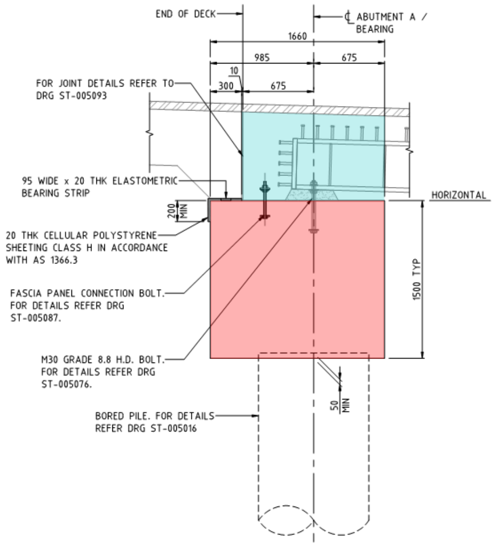
3.1 Preliminary Construction

A short construction period was an inherent requirement of the design. This was to minimize the effects of construction to both road traffic and rail operations. Construction activities over the rail corridor was also limited to weekend closures referred to as 'track possessions', which had to be requested and authorised by the rail authority.

Council granted a period of 16 weeks for closure of the bridge to road traffic. Only two track possessions were scheduled during this 16 week period. Beca and Abergeldie planned for all the required construction works to be completed within the first track possession, with the second as redundancy.

The following preliminary construction work was undertaken in preparation for the first track possession (see Figure 7):

- Closure of road to traffic
- Installation of new bridge piles
- Construction of new bridge abutments; with concrete poured up to horizontal construction joint



(red shaded portion in Figure 8).

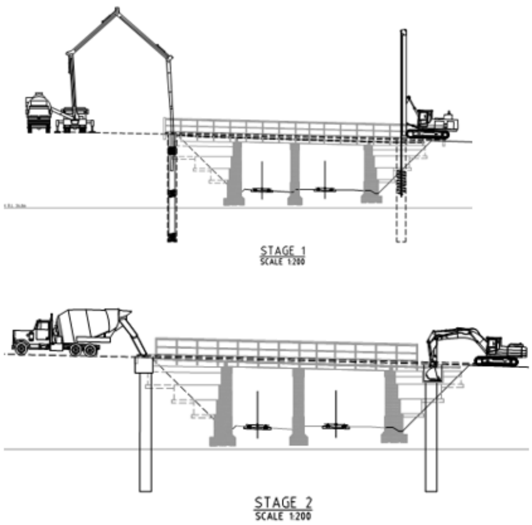


Figure 7. Stages 1 and 2 of construction work prior to first track possession

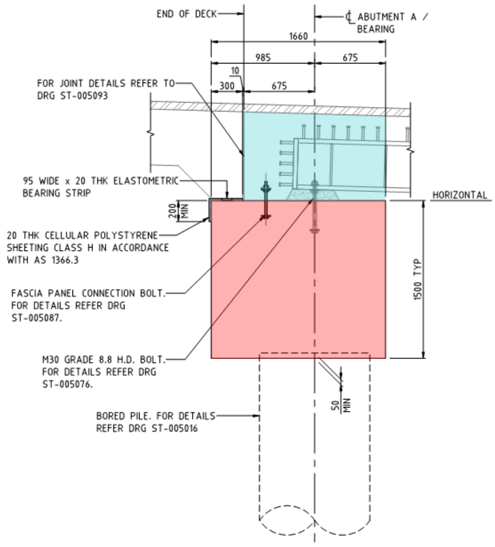


Figure 8. Section through headstock

In preparation for the demolition of the existing bridge during the first track possession, Abergeldie saw cut approximately 50-60% depth of the existing bridge superstructure through the crowns of the Jack Arches. 100 mm diameter core holes were then drilled to full depth through the crown of each arch on the saw cut line at predetermined locations; in which slings were fed through for lifting during the demolition process. The central masonry pier was also partially saw cut vertically into 6 No. 2.1 m pieces in preparation for demolition. The 2.1 m segments of pier was lifted using a lifting frame fabricated from

PFC sections bolted on either side of the pier segments. This enabled Abergeldie to lift and remove the central pier during the possession without causing damage to the adjacent rail infrastructure.

3.2 Track Possession Construction

The first track possession occurred during May 2016. The planned sequence of construction during the first possession were as follow (see Figure 9):

- Demolition of existing bridge superstructure and central pier
- Install temporary support for existing Telstra conduits
- Installation of new bridge girders
- Attachment of fascia panels and the anti-throw screens to the edge girders for the extent above the rail corridor
- Installation of FC sheeting formwork on girders

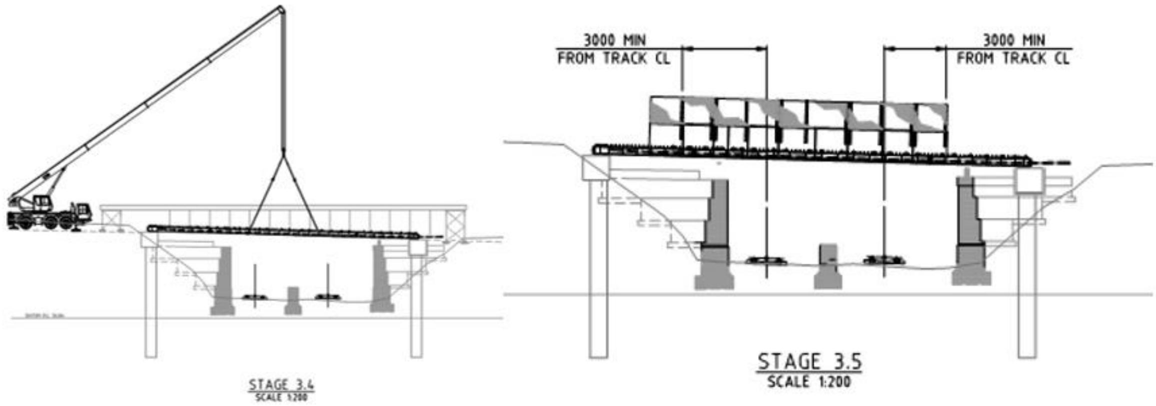


Figure 9. Erection of new girders and fascia panels

Beca proposed a steel support frame for the temporary support of the Telstra conduit. Ratchet straps were instead proposed and used by Abergeldie. These were tensioned and supported via PFCs anchored onto the partially constructed abutments. This provided a more cost effective means of supporting the conduit. It was also a quicker solution, eliminating the need for extensive fabrication.

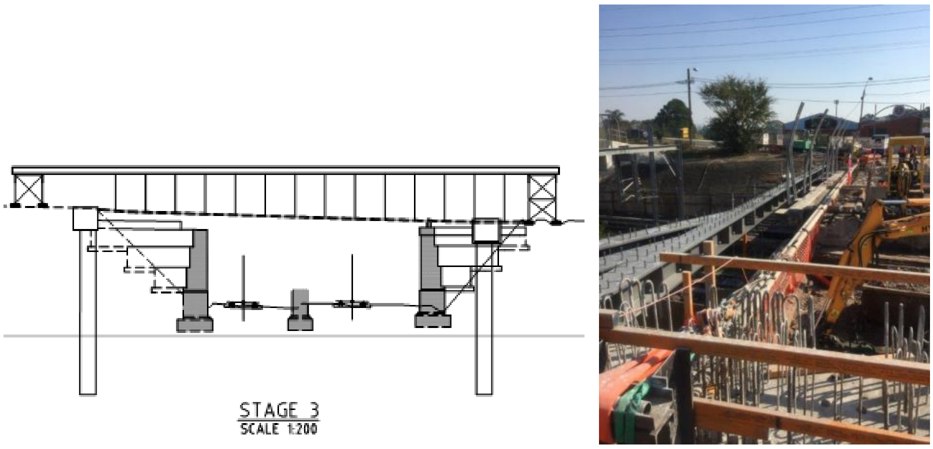


Figure 10. Temporary support of Telstra conduit

An issue was encountered during the demolition of the existing bridge superstructure, with the soil underneath the lifting crane settling during the lifting of the existing bridge segments. This was resolved via the provision of a larger crane pad. However, the issue caused delays and prevented the completion of all the planned construction activities listed above. By the end of the first track possession, Abergeldie had completed the demolition of the existing bridge superstructure, supported the Telstra conduits, but was only able to install the two outer steel girders. Removal of the existing bridge superstructure and the installed outer steel girders can be seen in Figure 11 and Figure 12 respectively below.

Beca instructed the installation a temporary support to maintain longitudinal (perpendicular to the rail tracks) stability of the central pier until the next track possession. As the existing bridge superstructure has been completely demolished during the first track possession, the central pier is now self-supporting and poses a risk of toppling over from wind and train collision loads. Since the central pier is not supporting the existing bridge anymore, it was not considered as a structural support structure and does not need to comply with the collision load requirements of AS 5100.2, however for compliance, it has to carry a specified 500kN load requirement. A temporary support consisting of PFCs is fixed to the top of the central pier and welded to the newly installed outer steel girders.

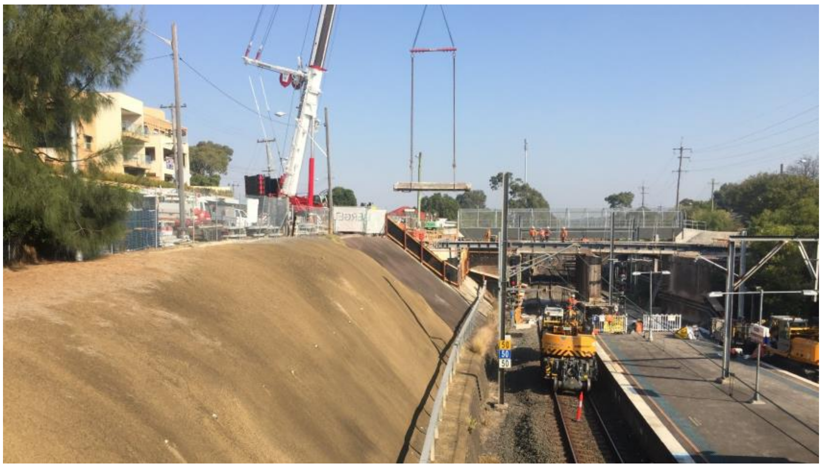


Figure 11. Removal of existing bridge superstructure

Figure 12. Installation of outer steel girders to allow for removal of central masonry pier at second track possession

With the installation of the steel girders incomplete, work on the bridge superstructure cannot be started. For the construction to continue while waiting for the next scheduled possession, construction of the approach slabs commenced (although this was scheduled to be start following the completion of the bridge superstructure). This is also to ensure that the target bridge opening date (September 2016) remains attainable even with the delay.

On the next possession (July 2016), the central pier was finally demolished and the remaining girders installed as well as the fascia panels which also serve as safety barriers for the construction personnel. Construction of the superstructure can now commence.

3.3 Remaining Construction

The provision of FC sheeting between the girder flanges served as formwork for the bridge deck and allowed the remaining construction activities to be carried out for the completion of the bridge superstructure while rail operations underneath the bridge continues. The FC sheeting and fascia panel barrier can be seen in Figure 13 below.

The erected steel girders were still simply supported during this stage of construction such that the steel girders alone cannot carry their own weight plus the weight of the wet concrete deck without the risk of the girders buckling. Due to this reason, the deck was cast in stages; with the abutments made integral prior to the central deck pour. The staging is illustrated in Figure 14 below. This also eliminated the need for temporary lateral bracing for the steel girders.

Figure 13. Work on the deck slab commenced upon completion of girder installation

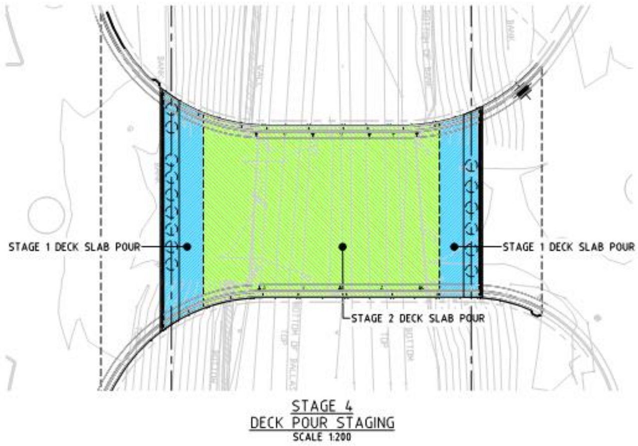


Figure 14. Deck pour sequence; Stage 1 in blue and Stage 2 in green

3.4 Completion of Construction

The new bridge was completed (except for the permanent anti-throw screen replaced by temporary ones) and was opened as scheduled at the end of September 2016. However, the permanent anti-throw screen was not installed as it is to be fixed outside of the bridge footprint and over the operational tracks. There is a risk of material falling onto the tracks and may cause an accident. Sydney Trains deemed that installation of the permanent anti-throw screens will require a track possession and as such, all stakeholders agreed to defer their installation to the next scheduled track possession (December 2016). The new bridge, as of November 2016 can be seen in Figure 15 and Figure 16 below.

Figure 15 – New overbridge today as viewed from Regents Park Station

Figure 16 - New overbridge today as viewed from road level

4 Conclusions

The following conclusions have been drawn from the Amy Street Intersection Upgrade:

- Understanding the requirements of the project and stakeholder requirements are very important in developing the design of a project
- Working on a project with a lot of constraints and challenges compels innovative thinking; with adaptive and reactive approaches to construction. Partially construction structural elements can be used for temporary support.
- Close coordination with all stakeholders (Council, Sydney Trains, TfNSW, Abergeldie) makes challenging projects easier as difficult decisions are collective made
- Careful planning is vital ingredient in the successful completion of the project. Planning in advance can provide a project programme with redundancies such that if a problem arose, a

quick and easy reallocation of work to another task, while finding a solution to that problem will help in keeping the project on schedule

5 References

[1] ESC 215 RailCorp Engineering Standard — Track Transit Space

[2] AS5100-2004 Bridge Design Set